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Testing of a Field Laundry Wastewater Recycling System

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This report describes the field testing of the Field Laundry Wastewater Recycling System (FLWRS) in conjunction with a military field laundry unit during a training exercise. Results indicated that the FLWRS is an effective method for treating laundry wastewater for reuse in laundry operations.

The testing indicated that the following modifications would improve FLWRS operations:

1. Withdrawing wastewater from the bottom center of the treatment tank and returning it to the top outer periphery during recirculation.

2. Installing a pressure gauge in the filter effluent line to allow monitoring of the pressure differential across the filter cake.

3. Adding treatment chemicals only when absolutely necessary to decrease total dissolved solids.

4. Providing instructions on changing chemical doses in accordance with changes in wastewater quality.

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4. Providing instructions on changing chemical doses in accordance with changes in wastewater quality.

FOREWORD

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CONTENTS

TESTING OF A FIELD LAUNDRY WASTEWATER RECYCLING SYSTEM

1 INTRODUCTION

Background

Fresh water supplies have normally been relatively abundant in areas where the U.S. Army has conducted military operations. Therefore, little attention has been given to availability of water supplies or water sources and the need to regulate or control water use in the field. Recently, the Army and Air Force have directed more attention to water resource management because of the increased costs of supplying and transporting water to combat areas and because of the growing prospect of deployment of forces to the Middle East or other arid regions. Water resource management options may be similar for rugged, mountainous areas, which have also been logistics problems. Thus, options such as water conservation, recycling, and reuse are being examined more closely.

Water supply and distribution are expected to be a major logistics effort in most water-short or water-critical areas of the world. Laundry operations are large users of water that could benefit from water management techniques in these scenarios. For example, one section of an Army field laundry (two washers and driers) requires 10,000 gal of water per 20-hour workday. However, use of a laundry waste recycling process could potentially save thousands of gallons of water per day for each field laundry unit and, at the same time, minimize the amount of wastewater discharged into the environment.

In 1975, the Army began developing a field Laundry Wastewater Treatment Kit (an item not presently in Army or Air Force Inventory). This kit is used to remove pollutants such as detergents and oils from laundry wastewater before it is discharged to the ground or released to streams or lakes. Treatment involves a batch process in which anionic and cationic polymers, along with powdered activated carbon, are added manually to each 500 gal of collected wastewater. The resulting treated water can be further polished using a diatomaceous earth filter and disinfected with chlorine for reuse in the laundry.

Pilot-scale evaluations of this concept have been successfully completed,[1] so field testing is the next step before implementation on a larger scale.

Objective

The objective of this study was to field-test the Field Laundry Wastewater Recycling System (FLWRS) in conjunction with a military field laundry unit during a military training exercise. The results would provide guidelines for operating the system and indicate the system's suitability to the military's needs.

Approach

On-site operational tasks, measurements, and laboratory analyses were performed to define the system's efficiency. Modifications were made as needed to improve operations. Results were analyzed and used as a basis for suggesting operating guidelines and methods to make the system more effective.

Users

The information in this report will be useful to companies and personnel responsible for water supply and logistics.

Mode of Technology Transfer

It is recommended that following completion of the development, procurement, and testing of the FLWRS, existing Field Manuals pertaining to laundry be amended or a new manual developed to include guidance in the use of this equipment.

2 EQUIPMENT

The FLWRS was field-tested at Fort McCoy, WI, from 10 to 15 June 1985. The test was conducted in conjunction with scheduled field exercises of the Laundry, Bath, and Renovation Platoon of the 106th Supply and Service Company, attached to the 426th Engineer Battalion of the Wisconsin National Guard.

[1] J. T. Bandy, et al., *Development of a Field Laundry Wastewater Recycling System*, Technical Report N-86/08/ADA 169585 (U.S. Army Construction Engineering Research Laboratory [USA-CERL] and Air Force Engineering and Services Center, 1986).

The recycling system used for the test was a batch treatment process that involved: (1) flocculation and sedimentation after the addition of powdered activated carbon and polymers to the wastewater, (2) filtration of the supernatant with diatomite filter, and (3) disinfection by adding calcium hypochlorite to the filtered water. USA-CERL Technical Report N-86/08 describes the treatment process equipment and the performance of the system during full-scale laboratory tests.

The FLWRS was colocated with a trailer-mounted laundry unit M-532, Zidal Model ELT QT (Figure 1). Water for that laundry unit and a nearby field bath unit, also operated by the 106th Supply and Service Company, was obtained from a nearby water hydrant on Fort McCoy. Laundry wastewater that was not treated and recycled and wastewaters from the nearby bath facility were discharged into the installation sewage collection system.

The equipment used in the FLWRS consists of items in the Laundry Wastewater Pollution Abatement Kit plus a military diatomite filter. The Pollution Abatement Kit is used to treat laundry wastewater before it is discharged. In many states, environmental regulations allow discharge of untreated laundry wastewater only to a sanitary sewer. Addition of the diatomite filter permits the water to be filtered and recycled for laundry purposes. Figures 1 and 2 show the principal components (described below) of the FLWRS used at the Fort McCoy location.

Wastewater Collection Tank

Wastewater from the laundry unit flows by gravity into a collapsible-fabric 500-gal pillow tank. The inlet to the pillow tank is about 2 ft lower than the laundry unit's drain outlet. During the tests, wastewater flow was intermittent because of the varying drain cycles from the laundry. For one load of washed clothes, about 50 gal of wastewater (one wash and two rinses) were collected every 30 minutes. The wastewater treatment process was not started until 500 gal of wastewater had been collected.

Treatment Tank

A 500-gal collapsible, open-top, fabric tank was used to treat the wastewater. The tank was erected on uneven ground, reducing the holding capacity to about 450 gal. A steel channel used as a top spreader for the open-top tank also held the suction and discharge pipes of the wastewater pump in position during the recirculation cycle. The suction pipe was positioned vertically downward from the top of the tank about 1 ft from the tank's outer periphery to withdraw treated water from near the tank bottom. The discharge pipe was similarly positioned opposite the suction pipe, 1 ft from the other side of the tank. The bottom side outlet, normally used as the tank drain, was connected to the diatomite filter pumps.

A 90-degree ell connector was installed inside the treatment tank at the bottom drain and positioned vertically upward. This allowed settled water to be withdrawn for filtration without disturbing the settled sludge. It also permitted 2 to 3 in. of settled sludge to remain in the tank for resuspension in subsequent treatment cycles. The settled sludge in the tank reduced the tank volume during subsequent refill cycles. On the average, an estimated 400 gal of wastewater were transferred from the pillow tank to the treatment tank. All treatment chemicals, powdered activated carbon (PAC), acid, cationic polymer-I, and anionic polymer-II were prepared using volumetric measures and manually added at specific times in the treatment cycle.

Diatomite Filter

A standard military diatomite filter with 0.4 sq ft of filter area, a filter pump, and all attached equipment needed to maintain a constant rate of filtration, precoat, and backwash were connected to the treatment tank. The filter was operated at a 7.0-gpm constant rate of flow over a variable pressure range. If the operating pressure exceeded 42 psig, a pressure relief valve discharge to waste, signaling it was time to backwash the filter. The filter was backwashed with an air/water reverse flow through the filter septa using less than 2 gal of filtered water. This was the only water lost in the backwash process. Settled water was not used to precoat the filter septa with fresh diatomite. Backwashing and precoating the filter took about 5 minutes. At this test site, an auxiliary tank was hard-piped to the filter to recirculate the precoat. The charge of diatomite poured into the filter was recirculated until all of the diatomite had been deposited on the filter septa. The filter pump was electrically driven, with power obtained from a 3-KW generator a Table of Equipment (TOE) item of the laundry platoon.

Filtrate from the diatomaceous earth filter was collected in a 200-gal auxiliary plastic tank and then pumped to the laundry unit as needed for laundry use. To maintain a chlorine residual in the filtered water storage tank, a concentrated solution of calcium hypochlorite was manually added to the water in the filtered water storage tank periodically.

Figure 1. FLWRS deployed at Fort McCoy, WI.

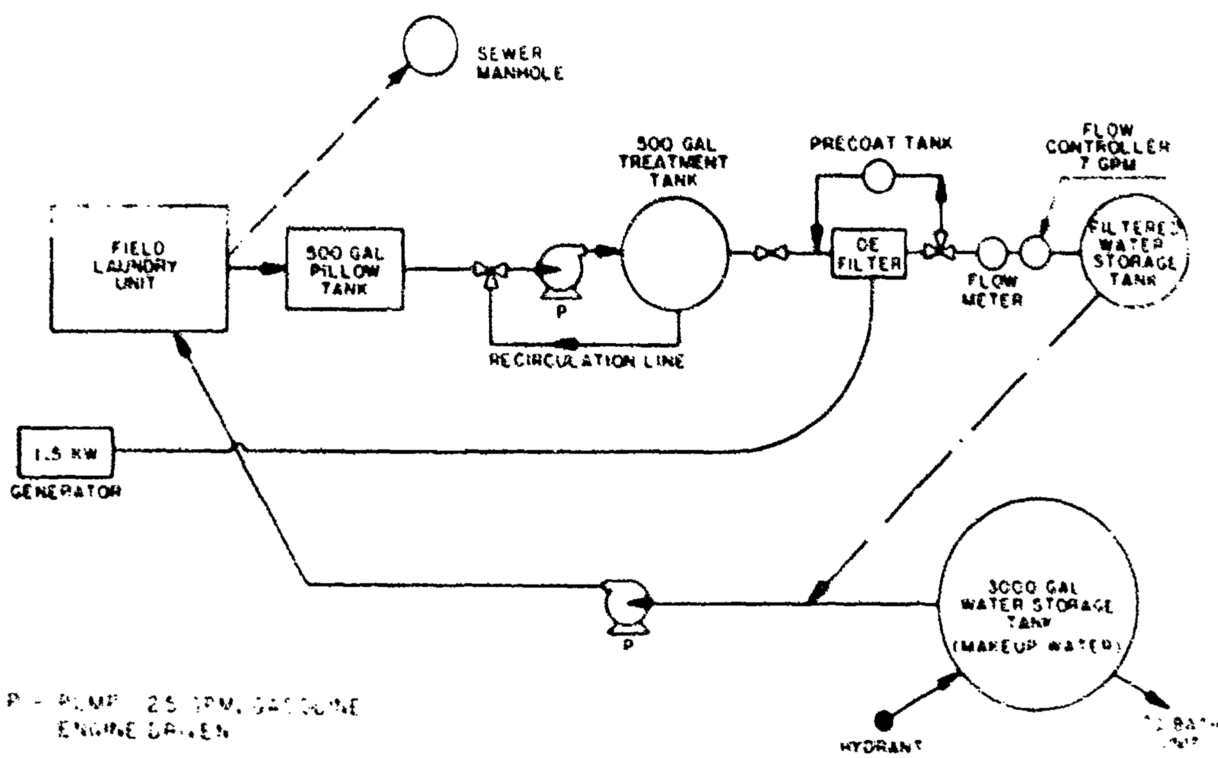

Figure 2. Laundry wastewater recycling system schematic, Fort McCoy field test.

3 OPERATING PROCEDURES

Generally, the chemicals used to treat the water were all volumetrically measured, quantities of water needed to operate the system were estimated, and process control changes were made based on operating observations; however, a few exceptions were made to help record some pertinent data. A totalizing water meter was installed to measure the amount of water filtered and a stopwatch used to time the treatment procedures. Chlorine residual and pH measurements were made on-site with a standard military color comparator. Water samples for other chemical and physical analyses were collected and transported to a field laboratory. Analyses were conducted and read later. To simplify or improve the treatment's efficiency, some changes in process control were made as different batches of wastewater were treated. The initial operating procedures were:

1. The laundry wastewater collected in the pillow tank was pumped to fill the treatment tank (about 450 gal). Prior to transfer of the wastewater, the stopper was inserted manually in the 90-degree ell in the bottom tank outlet.

2. About 6.5 lb (full 3-gal bucket) of powdered activated carbon, 2 lb of soda ash, and 450 mL of 66-degree baume sulfuric acid were added to wastewater in the treatment tank. Enough sulfuric acid was added to lower the pH below 8.0.

3. To obtain a good mixing of carbon, soda ash, and acid with the wastewater, the carbon-treated wastewater was circulated for 20 minutes, using the transfer pump.

4. The recirculation was stopped, and half the cationic polymer-I solution (about 37.5 mL or 25 mg/L) was added. The wastewater was stirred intermittently with a paddle for 30 minutes. The rest of the polymer-I solution (about 37.5 mL) was added after about 15 minutes of stirring.

5. The mixture was stirred for 30 minutes. The anionic polymer-II (15 mL dissolved in 1000 mL of water) was added, and the tank contents stirred manually for 5 minutes. (The polymer-II dosage was 1.0 mg/L.)

6. The mixture was stirred for about 5 minutes or until the floc formation was visible; the wastewater was then allowed to settle for 20 minutes.

7. The diatomite filter was precoated just before the settling period ended. A diatomite slurry of 0.6 lb of diatomite and 2 gal of water was prepared and poured into the diatomite filter shell; the slurry was recirculated for 5 minutes until the precoat layer was visible on the filter elements.

8. The stopper was removed from the 90-degree ell in the bottom tank drain, and the filter valves repositioned to put the diatomite filter in its service flow operating mode.

9. About 0.5 g of calcium hypochlorite was added to the filtered water storage tank. The chlorine dosage was repeated when the tank was half full. (Chlorine dosage of 0.5 g to 100 gal of water was about 1.0 mg/L.)

10. The diatomite filter was backwashed when influent pressure reached 40 psig. After dislodging the filter cake, the filter shell was drained to waste, and the filter elements precoated with new diatomite.

11. When the filtered water tank was nearly full, the existing hoseline was connected to the laundry unit, and recycling operations begun.

4 TESTING AND EVALUATION

Three water "batches" and seven "cycles" were completed during the field test. A "batch" began when feedwater for the laundry unit was withdrawn from the source water storage tank. A "cycle" consisted of collecting and treating about 500 gal of wastewater and recycling it as feedwater to the laundry unit. Since water remained in the washed clothes and there were losses due to filter backwashing, potable makeup water from the laundry water storage tank was added so that each cycle began with about 500 gals. Whenever a new batch was started, all treated wastewater was drained to waste and the laundry operations resumed using water from the installation until 500 gal of laundry wastewater had been collected again. Table 1 summarizes the test results.

Batch No. 1—Cycle No. 1

The first 450 gal of laundry wastewater collected were treated in accordance with the procedures outlined in Chapter 3. The floc formation and settling characteristics of the treated water were fair, and were typical of the first tankful of a new batch. Two runs

Table 1
Summary of FLWRS, Test Results, Fort McCoy, WI

Date (Batch/Cycle)	Wastewater Treated (gal)	Treatment Carbon (lb)	Acid (mL)	Soda Ash (lb)	Poly I (mL)	Poly II (mL)	Filter Run	Filter Gal	Sample*	Turb. (NTU)	Cl_2 (ppm)	Alk (ppm)	TDS (ppm)	pH	Remarks
										0.74	0.02	46	405	6.5	
10 June 85 (1/1)	450	6.5	450	2	74	15	2	160	W	191	0.1	88	150	8	
								110	S	3	0.15	540	2000	8	
									F	1.1	2.0	416	2050	7.6	
11 June 85 (1/2)	400	6.5	100	2	74	15	2	320	W	200	0.2	490	1900	8.2	
								26	S	4.4	0.2	415		7.7	
									F	0.54	0.3	445	2425	7.6	
12 June 85 (1/3)	400	5	100	2	74	15	1	340	W	347	0.2	395	2550	7.8	Relocated recirculation discharge hose and changed method of adding PAC.
									S	2.4	0.15	440		8.0	
									F	0.3	0.2	473	3000	7.9	
12 June 85 (2/1)	450	6.5	100	0	74	15	3	50 80 20	–	--	–	–	–	–	All sludge drained. Settled very poorly; no recycle.
13 June 85 (3/1)	450	6.5	15	0	140	15	2	327	W	200	0.1	160	1550	7.5	All sludge drained. Increased polymer-I dosage.
								93	S	7.8	0	115	525	8.0	
									F	0.9	0.2	125	625	7.3	
13 June 85 (3/2)	400	6.5	0	0	140	15	2	155	W	245	0.1	140	1333	7.5	Mixed polymer-II with pump generator stopped; backwashed mixed polymer-II for 20 min.
								176	S	3.4	0	160		8.8	
									F	3.7**	0.3	140	1250	7.2	
14 June 85 (3/3)	400	6.5	0	0	140	15	1	–	W	362	0.4	180	1000	7.5	
									S	3.1	0.2	170		8.8	
									F	2.5**	0.2	135	1000	8.8	
										0.75	0.2	46	405	6.5	Source water.

*W - Wastewater from laundry unit.
S - Settled water after carbon and polymer treatment.
F - Filtered water, di[illegible] ite filter effluent.

**Turbidity measured [illegible] rs after collection of sample.
Diatomite 0.6 lb/precoat.

were required to filter the tankful of settled water. The first run operated for 23 minutes before the filter was backwashed. Filtrate clarity was equivalent to that of the makeup water; however, alkalinity and total dissolved solids (TDS) in the filtered water increased significantly.

Batch No. 1–Cycle No. 2

Makeup water (130 gal) was added to replenish water lost in the backwash cycles and in the laundry operations. Treatment procedures for this cycle were identical to those followed in Cycle No. 1. However, only 400 gal of wastewater were transferred to the treatment tank and mixed with the settled sludge from the previous cycle. Improvement in the settling characteristics of this cycle could have resulted in the need for only one filtering run for all of the treated water. However, the filter was backwashed and stopped just prior to completion of a tankful of settled water because the 200-gal filtered water storage tank was overflowing. Normally, this would not occur because the water storage tank would hold at least 500 gal. Turbidity of the filtered water was excellent, but its alkalinity and TDS increased.

Batch No. 1–Cycle No. 3

To improve mixing of the carbon with the water and to reduce the need for manual stirring, several changes were made in the operating procedures for Cycle No. 3. The sulfuric acid, soda ash, and 6.5 lb of powdered activated carbon were added to the settled sludge just before the treatment tank was refilled. The discharge hose with pipe extension was relocated to direct the wastewater discharge toward the outer periphery of the tank and thereby tangentially rotate the tank contents. This same position was used for recirculation. At the same time, the suction pipe of the recirculation pump was relocated to the center of the tank. Also, the wastewater was not stirred manually after the polymer I was added.

The settling characteristics of the treated wastewater were excellent; the entire tankful was filtered in one run. Clarity of the filtered water was better than that of the makeup water; however, the alkalinity and TDS continued to increase. As a result, the laundry unit operator had to increase the quantity of soap during the wash cycle when he noted a reduction of sudsing. Therefore, all the treated water was drained to waste and a new batch started.

Batch No. 2–Cycle No. 1

Cycle No. 1 was started without any settled sludge in the treatment tank. The operating procedures were identical to those of Cycle No. 3 in Batch No. 1, except that no soda ash was added. The observed quality of the settled water just prior to the start of the filter run was poor. Although most carbon particles had settled, the supernatant remained very cloudy and its filterability was so poor that the filter operated for only 6 to 12 minutes. During this cycle, researchers noted that the 40-psig filter pressure was not a good criterion for determining when the filter should be backwashed. The procedure was then changed to backwashing the filter when the filter pressure relief vaive discharged to waste.

The clarity of the filtrate was so bad that it was thrown away instead of being returned for reuse. Therefore, a series of jar tests was conducted in the laboratory to determine a more effective treatment procedure. Test data (Table 2) based on laundry wastewater and chemical doses required to treat 500 gal of wastewater confirmed that wastewater could be improved if the pH was lowered to between 7.0 and 8.0 and if the polymer-I dose was increased.

It was later found that for Batch No. 2, the laundry unit operator had reduced the number of rinsing cycles from two to one because of the heavy clothes-washing load that day. This deletion of one rinse cycle increased the soap and suspended solids concentration and required the polymer dosage to be increased.

Batch No. 3–Cycle No. 1

The treatment tank was completely drained before the start of Batch No 3. The treatment procedures were the same used in Cycle No. 1–Batch No. 2, except that the dose of polymer-I solution was increased from 75 mL to 140 mL. The floc formation and settling characteristics of the carbon slurry showed a definite improvement over those of the previous day. More than 200 gal were filtered during the first filter run, and the filtrate quality was excellent. Nearly the whole tankful of settled water was filtered in one run, which indicates it was more filterable than the first cycle of previous batches. Since no soda ash was added, the alkalinity and TDS increased less than in Batch No. 1.

Batch No. 3–Cycle No. 2

Cycle No. 2 followed the same procedure as Cycle No. 1, except that less wastewater was transferred because of the amount of settled sludge in the treatment tank from the previous cycle. Also, when polymer-II was added, it was mixed by the recirculating pump, rather than manually. Floc formation and settling characteristics were excellent. The tank contents could

Table 2
Jar Test Data

Jar No.	Carbon (lb)	Soda Ash (lb)	H_2SO_4 (mL)	Polymer-I (mL)	Polymer-II gram	pH	Turbidity	Clarity
1	6.5	0	100	74	1	6.75	33	Poor (Note A)
2	6.5	2	450	74	1	6.2	41	Poor (Note A)
3	6.5	1	225	74	1	6.5	27	Poor[1] (Note A)
4	6.5	2	50	74	1	8	200	Poor[2] (Note A)
5	6.5	0	75	74	–	7.3	–	Better (Note B)
6	6.5	0	75	121	–	7.3	–	Best

[1] Slightly better appearing floc, but clarity not much different than No. 1 or No. 2.

[2] After polymer-II was added, the carbon particles coagulated and settled very rapidly, but the residual turbidity was very high.

Notes:

A When another charge of carbon was added to samples 1 through 4, no improvement in clarity was noted.

B When more polymer-I was added to bring dosage to 148 mL in sample 5, clarity improved.

have been filtered with one precoating except that the gasoline-engine-driven generator stopped. When the filter pump stops, the diatomite cake is dislodged automatically, and the filter must be backwashed.

Batch No. 3– Cycle No. 3

Cycle No. 3 was similar to Cycle No. 2, except that the mixing time for polymer-I was reduced to 20 minutes. It appeared that the rapid mix provided by recirculation through the pump was so effective that the mixing time could be reduced. Table 1 shows the results of this cycle.

5 DISCUSSION

Results of the field testing indicated that the FLWRS is an effective method for treating laundry wastewater for reuse. The system is easy to transport, set up, and operate, and provides recycled water of adequate quality for military laundry operations.

FLWRS Operating Requirements

For the field testing, the FLWRS treated wastewater from one trailer-mounted laundry unit. During the day, the laundry unit was operated almost continuously, and it took about 5 hours to collect 450 gal of wastewater. Since the FLWRS was operated as a batch process, treatment did not begin until at least one tankful (450 gal) of wastewater had been collected.

Once a batch is started, an operator must be available for the following duties:

1. Starting and stopping the gasoline-engine-driven recirculation pumps

2. Adding chemicals during the mixing cycles of treatment

3. Stirring the tank contents to mix the polymers

4. Starting and stopping the diatomite filter

5. Chlorinating the filtered water.

The sequence of steps used during the field test to treat a tankful of wastewater and the time required of the operator are summarized as Method A (Table 3). However, the procedures used in Method A (described above) did not always thoroughly mix the PAC with the wastewater. Clumps of unwetted PAC often floated on the surface of the recirculated water. Also, stirring of the polymer-I with a paddle was tedious and time-consuming. Based on these observations, the following changes were made.

1. The dry charges of PAC were placed in the bottom of the treatment tank prior to transfer of the wastewater. This provided better wetting of the carbon and improved the mix of chemicals with all of the water. Once wastewater began entering the "R" tank, the charge of sulfuric acid solution was added to the incoming flow.

2. The suction and discharge pipes were repositioned to allow the recirculated carbon-treated water to rotate around the tank. High annular velocities at the tank periphery decreased to nearly zero annular velocity at the center of the tank, which provided good mixing. Carbon particles settled first at the point of low annular velocity—at the suction pipe of the recirculation pump.

3. When the treatment tank was full, the polymer-I solution was added; recirculation continued for 20 more minutes. Theoretically, at the 125-gpm pumping rate, turnover of the tank contents would be four times in 20 minutes. However, since the 20-minute recirculation was chosen arbitrarily for the test, less recirculation time may have been adequate. When the recirculation was stopped, polymer-II solution was added to the water surface, and the operator stirred the tank contents with a paddle for 5 minutes.

These changes were implemented in treating Batch No. 3 and produced very satisfactory results, reducing both actual treatment time and operator time. These steps, and the time required by the operator, are summarized as Method B (Table 4).

At Fort McCoy, where only one laundry unit was operated, treatment often had to be stopped until more wastewater could be collected. This downtime could have been made to coincide with settling time, so that instead of a 25-minute settling period, the treated water would have settled for up to 150 minutes. Normally, increased settling time would make the settled water more filterable.

The improvements realized from using Method B procedures reduced the amount of operator time required. This reduction may have been sufficient to allow the laundry operator to perform the treatment

Table 3
Treatment Procedure – Method A

Operational Steps	Actual Treatment Time (minutes)	Operator Time (minutes)
Transfer wastewater to treatment tank	4	4
Recirculate wastewater; add PAC and acid	21	21
Add polymer-I and hand-stir	30	30
Add polymer-II and hand-stir	5	5
Settle treated water	25	–
Precoat filter	5	5
Filter water*	60	–
Total	150	65

*Based on one filter run per tank.

Table 4
Treatment Procedure – Method B

Operational Steps	Actual Treatment Time (minutes)	Operator Time (minutes)
Add PAC, wastewater	1	1
Transfer wastewater to treatment tank; add acid	4	4
Add polymer-I and recirculate	20	20
Add polymer-II and hand-stir	5	5
Settle treated water	25	–
Precoat filter	5	5
Filter water*	60	–
Total	120	35

*Based on one filter run per tank.

operations. However, this possibility could not be evaluated at Fort McCoy, because the automatic controls on this individual laundry unit were inoperable. As a result, the operator had to remain at the machine and manually control each wash and rinse cycle.

Impact of Laundry Wastewater Quality on FLWRS Operations

Both soda ash and sulfuric acid are provided as part of the Laundry Wastewater Pollution Abatement Kit. The soda ash increases the wastewater's alkalinity, and the sulfuric acid lowers its pH. These chemicals are used whenever needed to aid in floc formation and to improve the carbon/polymer-treated wastewater's settling characteristics. The operator cannot measure alkalinity and has only litmus paper to measure pH. Therefore, explicit instructions are needed to help him/her make the right choice, particularly for treating the first cycle of any one batch.

At Fort McCoy, both soda ash and sulfuric acid were added, and coagulation was satisfactory. The addition of soda ash overwhelmed the sulfuric acid, but the combination apparently did not affect floc formation adversely. However, adding soda ash in each subsequent cycle increased the TDS of recycled water too much. Since the souce/makeup water already had sufficient alkalinity, the additional soda ash was not required.

During the test, the quality of the wastewater changed when the laundry operator reduced the number of rinse cycles from two to one. This change was not readily apparent to the FLWRS operator until the filter operation was started. Again, instructions must be available so that the operator can adjust treatment procedures when conditions change. In this case, the floc particles were smaller than usual, and they did not settle well in the treatment tank. Here, instructions would inform the operator to increase the polymer-I dosage and recirculate or stir the contents until floc formation improved.

Adequacy of the FLWRS Equipment Set

Two men readily assembled the FLWRS at Fort McCoy in less than 1 hour. The components were off-loaded from a truck and carried manually to the operating site. The larger and heavier components are the diatomite filter and the recirculation pump; each requires two men to carry.

The field test provided a good evaluation of the equipment and suggested the changes described below to simplify operations and maintenance.

Precoat Recirculation

The diatomaceous earth filter used at Fort McCoy had a small auxiliary tank for recirculating the filter precoat. This recirculation ensures deposition of all the precoat charge on the filter septa. However, more than 90 percent of the diatomite added for percoating is deposited in the first pass, and recirculation recovers less than 10 percent. For treating wastewater, the 10 percent is not needed. Only 0.1 lb of diatomite per square foot of filter area is required to develop an adequate filter cake. An increase in the precoat charge would compensate for the diatomite lost if the recirculation process was eliminated. Without the recirculation equipment, the filter could be connected directly to the treatment tank with a hose.

Filter Pressure Gauge

The rate-of-flow controller on the filter effluent line pressurizes the filter to almost maximum pump pressure at the start of a filter run. The discharge of water from the pressure relief valve is the only reliable indicator of when the filter should be backwashed. Installing another pressure gauge in the filter effluent line would allow monitoring of pressure differential across the filter cake. When the pressure gauge reading decreases to near zero, the operator will know it is time to backwash the filter.

Recirculation of Wastewater

Relocation of the recirculation pump discharge line to provide tangential motion to the recirculated wastewater in the treatment tank requires a better method for holding the discharge hose in place. The present 3-ft pipe extension and 90-degree ell on the discharge hose should be replaced with a shorter piece of pipe; a strap fastener should also be added to hold the hose against the inner periphery of the treatment tank.

Additional Equipment

The following additional equipment would improve FLWRS operations:

1. A manually operated mechanical timer for timing mixing periods and adding chemicals.

2. Graduated containers for properly measuring chemicals.

3. A start-stop electrical switch on the filter pump to control its operation.

4. A protective baffle for the 90-degree ell in the bottom drain of the treatment tank to prevent settled carbon from entering the suction line to the filter.

5. A 500-gal storage tank to collect filtered water.

6. An adapter to permit the laundry feedwater hose to be connected to the threaded fittings on the FLWRS.

6 CONCLUSIONS AND RECOMMENDATIONS

Field testing of the FLWRS at Fort McCoy, WI, indicated that this sytem is an effective method for treating laundry wastewater for recycle in laundry units.

Withdrawing wastewater from the bottom center of the treatment tank and returning it to the top outer periphery during recirculation provides a rotating motion to the tank contents that improves chemical mixing and reduces manual stirring requirements.

When precoating the filter, additional equipment is not needed to recirculate the diatomite slurry.

Backwashing the filter when the pressure differential across the filter cake exceeds 40 psig is necessary.

The increase in TDS of recycled water limits the number of cycles that wastewater can be used. Consequently, treatment chemicals, such as soda ash and sulfuric acid, should be added only when necessary.

The FLWRS can satisfactorily treat 400 gal of laundry wastewater in 2 hours with an operator on duty for only about 30 percent of this time.

The FLWRS operator needs a manual with detailed information on how to change chemical doses in accordance with changes in the wastewater's quality.

Results of this field test produced the following recommendations for making FLWRS operations more effective:

A manual should be developed that provides instructions for changing or adjusting the chemical dosages based on the operator's observations rather than on laboratory data such as alkalinity, hardness, and jar test analysis.

Testing should be performed to determine the need to recirculate the diatomite precoat slurry.

A pressure gauge should be installed in the filter effluent line to indicate when the filter needs backwashing.

The FLWRS should not be used to treat more than 250 gph of laundry wastewater; if wastewater is generated at rates less than 250 gph, the additional time should be used to increase the solids settling.

A means of reducing the hardness buildup in recycled water should be provided.

Metric Conversion Factors

1 gal	=	3.785 L
1 ft	=	0.3048 m
1 in.	=	25.4 mm
1 sq ft	=	0.092 m^2
1 psig	=	703.070 kg/m^2
1 lb	=	0.453 kg

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